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ABSTRACT

This paper addresses how to help learners navigate in existing Web-based learning resources. In order to resolve this issue, a learner-centered navigation path-planning model is proposed. The main objective is to provide learners with a path planning space in which they can see through hyperspace to plan a navigation path. This paper describes an assistant system called Planning Assistant (PA), which is composed of the resource map, page previewer, and path previewer. The page previewer generates an overview of each Web page in the map by extracting representative information from the HTML file. The path previewer helps learners make a sequence of the pages previewed as a navigation path plan. These facilities help learners decide which pages to visit and to plan a navigation path without visiting Web pages. This paper also describes an evaluation of learner-centered path planning with PA. The results indicate that PA facilitates learners' navigation in hyperspace, particularly in more complicated hyperspace. (Contains 10 references.) (AEF)

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A Navigation Path Planning Assistant for Web-based Learning

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Abstract: The main topic addressed in this paper is how to help learners navigate in existing web-based learning resources. In order to resolve this issue, we propose a learner-centered navigation path planning. The key idea is to provide learners with a path planning space, in which they can see through hyperspace to plan a navigation path. This paper describes an assistant system called Planning Assistant (PA for short), which is composed of the resource map, page previewer, and path previewer. The page previewer generates an overview of each web page in the map by extracting representative information from the html file. The path previewer helps learners make a sequence of the pages previewed as navigation path plan. These facilities help learners decide which pages to visit and plan a navigation path without visiting web pages. This paper also describes an evaluation of leaner-centered navigation path planning with PA. The results indicate that PA facilitates learners' navigation in hyperspace, particularly in more complicated hyperspace.

Introduction

An increasing number of hypermedia-based resources on the web have been available, which are designed from an educational point of view, or which are worth learning (Brusilovsky, 1996). Learning with such existing web-based learning resources has accordingly become important, particularly as the realization of lifelong and distance learning (Kashihara, 1998).

Web-based learning resources provide learners with hyperspace where they can explore domain concepts in a self-directed way by following the links among web pages to achieve a learning goal. Such self-directed learning (Fischer, 1998, Dee-Lucas, 1996) could produce good results. On the other hand, learners often fail in making the navigation path since they do not know which link to follow for achieving their learning goal due to the complexity of hyperspace. They may alternatively make diverse cognitive efforts at comprehending the contents of pages, setting up global or local learning goals, making a path called navigation path attaining their goals etc., in the exploratory learning. How to facilitate learners' navigation and learning has been consequently a major issue in educational hypermedia systems (Conklin, 1987).

The main topic addressed here is how to help learners navigate in existing web-based learning resources. Current work on educational hypermedia systems has provided a number of navigational aids such as spatial/concept maps and adaptive navigation (Domel, 1994, Heiling Huai, 1997). These representative navigational aids would generally work well in educational hypermedia whose semantic structure has given or analyzed. However, it is doubtful whether they apply to web-based learning resources. Existing web-based learning resources mostly have no concept maps. It is also hard to identify semantic structure of domain concepts embedded in the learning resources. Although there exist web-based learning resources with site maps, the information included in the maps do not always allow learners to foresee the contents of the web pages. In addition, adaptive navigational aids are not always applicable since existing web-based learning resources generally have no clear description of semantic relationships among web pages, which is indispensable for executing the adaptation.

Towards this issue, we introduce a learner-centered navigation path planning. The key idea is to provide learners with a planning space, in which they can see through web-based learning resources to make a navigation path plan, apart from hyperspace. Such planning space is also expected to facilitate their learning since they can focus mainly on comprehending the contents of the learning resources in hyperspace. We have accordingly developed an assistant system for the navigation path planning, which is called Planning Assistant or PA for short. PA provides learners with some facilities that help learners decide which page to visit and plan a navigation path without visiting hyperspace.

This paper also describes an evaluation of learner-centered navigation path planning with PA. The results indicate that PA facilitates learners' navigation particularly in more complicated hyperspace.

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Navigation Path Planning

Problems of Navigation in Hyperspace

In hyperspace, learners can explore the web pages in a self-directed way by following links among the pages to learn domain concepts embedded in the explored pages. The self-directed learning involves making a navigation path, which consists of pages that the learners decide to explore. However, they often fail in making the navigation path and reach an impasse. There are two main causes as follows.

- The learners cannot foresee what they should explore next from the current page for achieving their learning goal due to the complexity of hyperspace.
- The learners need to concurrently make diverse cognitive efforts not only at making a navigation path but also at setting up global/local learning goals, comprehending the contents explored, and so on.

Framework of Navigation Path Planning

Let us now introduce a framework for learner-centered navigation path planning in order to resolve the above navigation problems. There are two key points of the learner-centered navigation path planning. The first one is to divide learning process into navigation path planning and exploration (plan execution) phases as shown in Figure 1. In the planning phase, learners decide which page to visit and the sequence of pages visited. In the exploration phase, on the other hand, they are expected to explore hyperspace according to their navigation path plan. These phases are repeated during learning in hyperspace.

The second key point is to provide learners with planning and exploration spaces. In the planning space, learners can see through hyperspace provided by a learning resource to plan a navigation path. In the exploration space, on the other hand, they are expected to execute their navigation path plan. Such distinction allows the learners to focus mainly on cognitive efforts that are related to each phase.

We next discuss how to support learner-centered navigation path planning with some essential facilities for each phase.

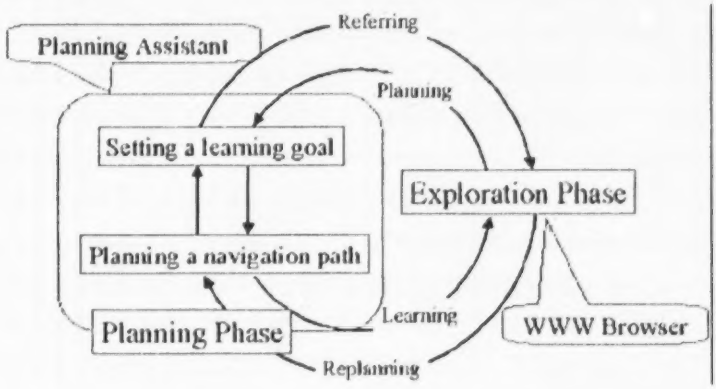

Figure 1: Learning process

Support for Planning Phase

In order to plan a navigation path successfully, it is first important to get information for setting up global/local learning goals. Some existing educational hypermedia systems have provided the resource map, which represents hyperspace as network of nodes corresponding to web pages. Although the resource map provides learners with information for considering navigation path, the map alone may not always allow them to sufficiently foresee the contents of the web pages. Therefore, some additional information is required. However, planning with the full contents of the web pages causes the same navigation problem as hyperspace usually produces. This suggests the necessity to give learners an informative overview of the contents. In this paper, we introduce page previewer that tries to extract keywords, sentences, or images to be considered representative from a web page to display them as the preview of the page. The resource map with the page previewer enables learners to grasp not only the whole structure of web-based learning resource but also an overview of each web page. Referring to this information, the learners can consequently set up learning goals easily.

In addition, the navigation path planning involves considering the relationships among web pages explored, changing the plan, and replanning over again. We accordingly introduce the path previewer, which makes a sequence of the previewed pages that are put in order by learners. The path previewer enables learners to compare neighboring pages and to plan a navigation path for achieving their learning goal without visiting hyperspace. Since the navigation path also gives learners an overview of the contents to be learned as advanced organizer before exploring hyperspace, their learning in hyperspace can be improved (Ausubel, 1961).

Support for Exploration Phase

After the planning phase, learners are expected to follow their navigation path plans during the exploration phase. We accordingly introduce the navigation controller that enables them to explore along their navigation path plan in a simply way. However, the learners do not always need to follow the navigation path. They can explore pages that are not included in the navigation path with web browser. When they want to change or cancel the navigation path during the exploration, they can return to the planning phase.

Planning Assistant

Let us next demonstrate PA. Figure 2 shows the user interface of PA, which consists of the resource map, the page previewer, the path previewer and the navigation controller. PA has been implemented with Microsoft Visual Basic 6.0 as plug-in tool for Microsoft Internet Explorer 4.0 (IE for short) or higher.

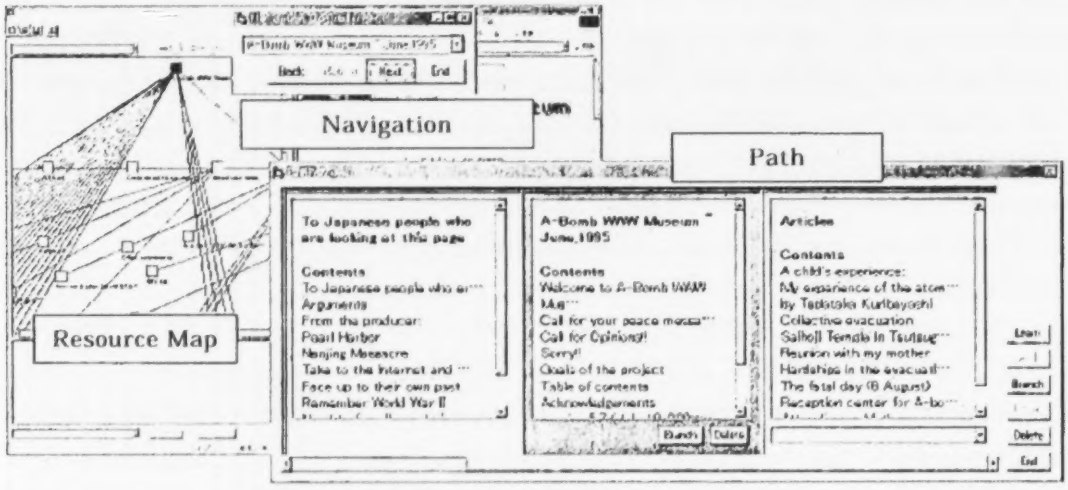

Figure 2: User Interface

Resource Map

The resource map represents hyperspace of a web-based learning resource selected by learners as network of nodes corresponding to the web pages. It is automatically generated and displayed in the map window when they select the learning resource. The resource map represents the web pages only within the same web site where the homepage selected by the learners is located. The links from the site to others are omitted. Nodes in the resource map are tagged with page titles indicated by title tags in the html files. In addition, we added a title list of all pages in the web site. These facilities enable learners to decide from which page to start their navigation path planning. In selecting a node or title, they can have an overview of the web page with the page previewer.

Page Previewer

The page previewer extracts key information such as words, sentences of images attached to some html tags in a page selected and displays it as an overview of the page. Table 1 shows the html tags that can be considered representative of the page, and Figure 3 shows an example of the page previewer. The right

window displays the preview of a web page shown in the left window. As for the links out of the page, the page previewer searches for <A href> tags in the html file, and displays all titles of the linked pages in the drop-down menu as link list at the lower part of the page previewer. In planning a navigation path, the learners can start the path previewer by pushing the 'Path' button in the page previewer.

Table 1: Html tags

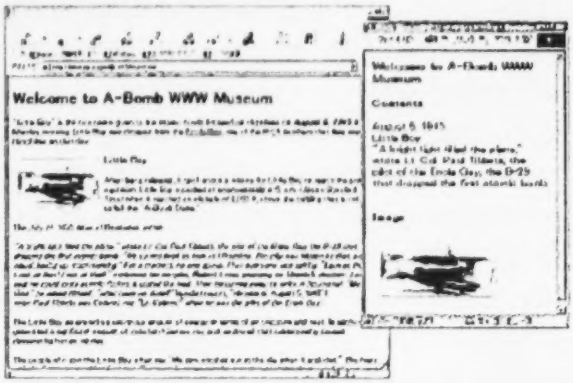

Figure 3: An example of the page previewed

Path Previewer

The path previewer makes a sequence of pages learners have previewed, which pages are put in order by learners. The order of the previewed pages accordingly represents a navigation path plan. How to plan a navigation path is as follow, (i) learners select a next page from the link list which displays titles of the pages directly linked to the current page, (ii) the path previewer displays an overview of the page selected next to the current page, (iii) if they want to add the page into the sequence, push the "Add" button it and return to (i), and (iv) if they do not want to add the page selected, return to (i) and select a next page again. In this way, the path previewer helps them plan (add, delete and branch), change, and replan their navigation path.

Navigation Controller

The navigation controller enables learners to explore along their navigation path plan in a simple way. Pushing ' Next ' button, the learners can explore the next page on their navigation path plan. They can also explore pages that are not along their navigation path plan. When the page explored by them is not along their plan, the navigation controller puts a warning icon and shows 'Return' button in order to come back on their navigation path plan. When they also want to change or cancel the navigation path during the exploration, they can return to the page previewer and the path previewer from the node corresponding to the current page on web browser.

In this way, learners are expected to repeat the planning and exploration to accomplish their learning in a self-directed way.

Evaluation

Purpose

In order to evaluate the effectiveness of PA, we conducted an experiment. The main purpose of this experiment was to ascertain if PA facilitates navigation in hyperspace compared to navigation without PA. We prepared two learning resources, which had comparatively simple and complicated hyperspace, and ascertained for which resource PA supports navigation more effectively.

Domain and Subjects

Table 2 shows the two learning resources ([1], [2]). It describes the number of pages, the number of links per page, which was calculated except for navigation links such as Next, Back, and Top, and the longest distance from the homepage to terminal page that has no link. These can be viewed as the indicator of the

complexity of hyperspace each learning resource provides. The learning resource 1 accordingly had a more complicated hyperspace. Subjects were 32 graduate and undergraduate students in science and technology who

Table 2: Learning Resources

were not familiar with the domain of the learning resources.

We set four conditions, which were (1) planning and execution with PA in learning resource 1 (Complicated-With), (2) exploration in learning resource 1 without PA (Complicated-Without), (3) planning and execution with PA in learning resource 2 (Simple-With), (4) exploration in the learning resource 2 without PA (Simple-Without). Subjects were provided with IE as web browser under each condition. In this experiment, each subject learned one learning resource without PA and learned the other with PA. Moreover, we assigned the subjects into four groups in order to counterbalance these conditions.

Procedure

The procedure of the experiment with each subject was as follows:

(1) He/she was given the explanation about how to use PA.
(2) He/she was given several problems as learning goals for learning resource 1 (or resource 2). The problems were classified into (a) single problem whose answer could be found within one web page, and (b) compound problem whose answers could be found in the relationships among two or three pages.
(3) He/she was required to explore answers to the single problems and compound problems within 15 minutes each with PA (or without PA), and to copy and paste the URLs of the web pages considered as the answer.
(4) When he/she finished finding out the answers or 30 minutes passed, he/she was given several problems for another resource and was required to repeat the same way with another condition.
(5) Comparing the scores and the behavior of subjects under Simple-With and Simple-Without or under Complicated-With and Complicated-Without, we evaluated the effectiveness of PA.

We measured three criteria that were 'achievement', 'accuracy', and 'efficiency' of navigation, which were calculated from the scores. 'Achievement' was calculated from the number of questions they answered within time limit (15 minutes for each condition). 'Accuracy' was the percentage of correct answers per the answered questions. 'Efficiency' was calculated by multiplying 'achievement' and 'accuracy'.

We also measured the influence on navigation in hyperspace by the number of revisited pages and a number of visited pages per all pages included in the learning resources, which were indicated from the behavior of subjects.

Results and Discussion

Table 3 shows the average of the 'achievement', the 'accuracy', and the 'efficiency' on each condition. As for the compound problems, the average of the 'accuracy' on Complicated-With was significantly higher than that on Complicated-Without ($F=11.14$, $p<0.01$). The average of the 'efficiency' on Complicated-With was also higher than that on Complicated-Without ($F=21.34$, $p<0.01$). From these results, it was ascertained that PA enabled learners to plan a good navigation path for achieving their learning goals especially such as

Table 3: Experimental Result

relating web pages each other in more complicated hyperspace. In a simpler hyperspace, on the other hand, PA could not be so effective since it was able to easily see through the learning resource even without PA.

Table 4 shows the average number of revisit per page explored on each condition. The results indicate that there is a significant difference between the average number of Simple-With and Simple-Without ($F=29.10$, $P<0.01$). There is also a significant difference between Complicated-With and Complicated-Without ($F=63.83$, $P<0.01$). These results indicate that PA reduces learners' behavior of revisiting the pages that have been visited both in simple and complicated hyperspace. In other words, PA enables learners to see through learning resources.

Table 5 shows the average number of visited pages per all pages on each condition. There was a significant difference between Simple-With and Simple-Without ($F=46.19$, $P<0.01$). There is also a significant difference between Complicated-With and Complicated-Without ($F=183.18$, $P<0.01$). These results indicate that PA makes exploration in hyperspace intensive. In addition, the average of 'efficiency' on Complicated-With was very high as shown in Table 3. These results indicate that PA enables learners to more efficiently direct their attention to pages, which fulfill their learning goals, particularly in a complicated hyperspace. From the above results, we can say that PA has a potential for facilitating navigation in a more complicated hyperspace.

Table 4: The average number of revisit pages

Table 5: The average number of visited pages per all pages

Conclusion

This paper has proposed a learner-centered navigation path planning for learning with existing web-based resources. The important point is to provide learners with a planning space where they can see through the web pages to plan a navigation path. As the advantages, learning in hyperspace can be improved since the distinction between planning phase and exploration phase allows learners to focus mainly on comprehending the contents of the learning resources in hyperspace. The navigation path can also give learners an overview of the contents to be learned before exploring hyperspace.

This paper has also demonstrated a support system called PA including the resource map, the page previewer, the path previewer, and the navigation controller. These facilities allow learners to plan and explore a navigation path plan in a simple way. In addition, this paper has described an evaluation of PA. The results indicate that the system produces good effects on navigation in a complicated hyperspace.

In the future, we need a more detailed evaluation of the learner-centered navigation path planning. We would also like to provide more adaptive aids in the page and the path previewer.

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[1] http://www.cubas.co.jp/index.htm

[2] http://www.inseki.gr.jp/~kenyao/index.htm

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